FINAL

POST-REMEDIAL ACTION REPORT FOR THE MADISON FUSRAP SITE

MADISON, ILLINOIS

SEPTEMBER 2000

U.S. Army Corps of Engineers
St. Louis District Office
Formerly Utilized Sites Remedial Action Program

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prepared by

U.S. Army Corps of Engineers, St. Louis District Office, Formerly Utilized Sites Remedial Action Program

with assistance from

Science Applications International Corporation
under Contract No. DAHA90-94-D-0007, Delivery Order 1004

Errata Sheet for the
Post Remedial Action Report for the Madison FUSRAP Site
Madison, Illinois
September 2000
U.S. Army Corps of Engineers, St. Louis District Office, Formerly Utilized Sites Remedial Action Program

1. Page 10, Section 5.2, First paragraph, 2nd Sentence. Change from "excluding Class 2 and Class 3" to "excluding all Class 2 and Class 3"
2. Page 11, Section 5.4, 2nd Sentence. Change "USACE certified laboratory for isotopic..." to "USACE validated laboratory, located at 8945 Latty Avenue in Berkeley, Missouri was used for isotopic analysis". USACE does not validate, it certifies laboratories.
3. Page 11, Section 5.5, 4th Sentence. Change from "Svern Trent Laboratories analyzed the split samples" to "The USACE validated laboratory, Svern Trent Laboratories, perfromed the QA / QC analyses on the split samples."
4. Figure 3, Legend. Add an unfilled circle to the legend with the text "The unfilled circles represent biased samples collected on cross member structure surfaces other than truss beam surfaces."
5. Figure 4, Legend. Add an unfilled circle to the legend with the text "The unfilled circles represent biased samples collected on cross member structure surfaces other than truss beam surfaces."
6. Figure 9, Legend. Add note to state: "The orange dots represent samples collected on cross members. Note that they do not have sample numbers because there were no measurements that exceeded even a small fraction of the DCGL in this survey unit."
7. Appendix A. Signed Field Work Variances are maintained in the USACE contract files.

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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
CFR	Code of Federal Regulations
cm	centimeter(s)
COC	contaminant of concern
DCGL	derived concentration guideline level
DOE	Department of Energy
dpm	disintegration per minute
FSSP	Final Status Survey Plan
ft	feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
m	meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
MED	Manhattan Engineer District
mrem/yr	millirem per year
pCi/g	picocuries per gram
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SU	survey unit
U	uranium
USACE	United States Army Corps of Engineers
WRS	Wilcoxon Rank Sum

Executive Summary

Background

The Madison Site, located in Madison, Illinois was used to perform extrusions of uranium metal and straightening of extruded uranium rods for the Atomic Energy Commission (AEC), the predecessor agency of the Department of Energy (DOE), during the late 1950s and early 1960s. The work was conducted in Building 6, a large multi-story metal building with a concrete floor. The adjoining Building 4 was used for material transfers. The AEC-funded operations resulted in residual radiological contamination in dust on overhead steel beams in the plant. The DOE indicated that no other operation or period of involvement with the processing or handling of FUSRAP related material at the Madison Site has been discovered.

The entire Madison Site consists of a large, multi-sectional complex of 10 interconnecting buildings with a total under-roof area of about 130,000 square meters (m^2) [1.4 million square feet (ft^2)]. The areas within the scope of the remedial action and subsequent verification surveys were limited to Buildings 4 and 6 of the facility. Interior structure surfaces in the vicinity of the extrusion press in Building 6 were the primary focus of the evaluation. The characterization survey performed by the United States Army Corps of Engineers (USACE) in 1998 also addressed other interior surfaces in Buildings 4 and 6, the exterior Building 6 roof, ground areas immediately outside doors of Buildings 4 and 6, surfaces of the extrusion press and adjacent equipment, and floor penetrations (pits, trenches, etc.) in the immediate vicinity of the extrusion press. Because historical site information and the results of the scoping/characterization survey indicated that facility areas (other than of Buildings 4 and 6) were not impacted, remedial action and final status survey of the entire facility was not required.

The building structures consist of steel columns on approximately 7.6-m (25-ft) centers, connected by trusses and multiple smaller vertical and horizontal cross members. Walls are concrete block with some brick veneer. Floors are concrete; with rough and pitted surfaces.

Remedial Action Guidelines

The remedial action guidelines for the remediation of the Madison Site were established in the Record of Decision (ROD) (USACE, 2000b). Specifically, the ROD established guidelines for satisfying the 25 millirem per year (mrem/yr) dose limit as described in the Code of Federal Regulations (CFR) Title 10 Part 20 Subpart E. Conservative dose calculations using site-specific information indicated that the derived concentration guideline level (DCGL) for surface contamination was 6000 disintegrations per minute (dpm) per 100 cm^2 and the volumetric (dust) DCGL was 20 pCi/g of total uranium (U-238 plus U-235 plus U-234). These DCGLs satisfy the 25 mrem/yr dose criterion. A volumetric limit of 300 pCi/g (also corresponding to the 25 mrem/yr dose criterion) was also established for the difficult-to-access overhead surfaces. Difficult to

access areas were defined in the ROD as "those areas above the window sills at an elevation from 13.7 to 18.3 meters (m) [45 to 60 feet (ft)] above the area containing the extrusion press. To assure that remedial and final status survey activities satisfy the 25 mrem/yr criterion, the *Final Status Survey Plan for the Madison FUSRAP Site – Madison, Illinois* (FSSP) (USACE, 2000c) evaluated data using the following six questions:

- Is the radiological COC below the 6000 dpm/100 cm^2 limit on Class 1 overhead surfaces and Class 2 and 3 building and equipment surfaces?
- Is the radiological COC below the 20 pCi/g limit in accumulated dust on Class 2 and Class 3 overhead surfaces?
- Is the radiological COC below the 300 pCi/g limit in accumulated dust on the difficult-to-access overhead surfaces?
- Do small areas of elevated radioactivity produce utility worker doses less than 25 mrem/yr?
- Is the residual dose to the modeled utility worker ≤ 25 mrem/yr?
- Do surface contamination sample/measurement results satisfy the Wilcoxon Rank Sum (WRS) statistical test as described in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)?

If the answer to any one of these questions had been "no" for any survey unit (SU), cleanup goals would not be satisfied for that SU and the remediation contractor would be required to remove additional building and/or equipment surface contamination and reevaluate the affected survey unit.

Remedial Action Summary

Remediation of the impacted Class 1 areas at the Madison Site involved the removal of radioactively contaminated dust from accessible overhead surfaces (horizontal surfaces including window ledges, utility conduits, trusses and cross member beams at heights of approximately 25 to 36 ft). Nearly 60,000 pounds of dust and debris were removed from the Class 1 areas which was shipped to a properly permitted out of state facility. The areas above the windowsills, starting at the top chord of the building trusses, were difficult-to-access due to overhead obstructions and constraints of lifting devices. These areas did not require remediation because sampling results from this area demonstrated that the dust on those surfaces averaged less than the volumetric DCGL criteria applicable to these 'difficult-to-access" areas.

Although the current and expected use of the Madison Site is industrial, remediation of the MED / AEC contamination at the facility achieved "radiological criteria for unrestricted use" specified in 10 CFR 20.1402 without regard to future land use.

Post Remedial Action Measurements

Buildings 4 and 6 were divided in accordance with MARSSIM (DoD et al. 1997) into Survey Units (SUs) according to MARSSIM classification. The SUs were originally defined as prescribed by the FSSP. Some minor adjustments were made during the final status surveys when contamination above the volumetric DCGL was discovered in Class 2 areas.

MARSSIM guidance for structures was followed for walls and floors. The concern at the Madison Site was primarily contamination on the horizontal surfaces of overhead structural members including trusses, cross members, braces, sag rods, I-beam roof supports, pipe runs, and window ledges which do not fit readily into the MARSSIM framework. The boundaries of the Class 1 SUs were selected to ensure that the horizontal surfaces of the main structural beams represented approximately 100 m^2 or less of the total surface area of any Class 1 unit. The truss "V" sections, cross members and bracing may add up to an additional 100 m^2 to each survey unit.

Additional Class 2 SUs, illustrated in Figures 5 and 6, were defined for the equipment and floor beneath the Class 1 overhead structures scheduled for remediation. The Class 2 units were set at approximately 1000 m^2 or less.

The remainder of the overhead structure surfaces, floor area, equipment, and walls in Buildings 4 and 6 were classified as Class 3 SUs.

Five types of measurements were made during the final status survey to determine whether the remedial action had met the applicable DCGL. These consisted of:

1. Surface beta scans to identify potential locations of elevated activity;
2. Fixed point measurements of total beta surface activity;
3. Fixed point measurements of total gamma dose rate;
4. Sampling of surface dust and residue;
5. Discrete measurements of removable alpha and beta surface activity.

Of these, the fixed point beta measurements (item 2) and dust/residue samples (item 4) were used to compare against the 6000 dpm/100 cm^2 and 20/300 pCi/g criteria, respectively. The other measurements were taken for completeness and to assess residual dose following completion of remedial activities, as necessary. Areas that contained residual contamination above the DCGLs were investigated and remediated, as appropriate.

Post Remediation Status

The cleanup criteria presented in the ROD are satisfied if the average concentration in a SU is less than the appropriate DCGL value. The analytical results for the final status survey samples/measurements indicate that the residual radioactivity at the

Madison Site meets the requirements of the remedial design and are below the dose-based guidelines.

In addition to evaluating the data against the cleanup criteria established by the ROD, dose calculations were performed to determine the dose to the potential maximally exposed individuals. The site-specific dose assessment was performed even though all systematic and biased samples (including dust sample results) and fixed point measurement results were below their respective DCGL values. The data shows that, using the dose models described in the Remedial Investigation (RI) and the ROD, doses to potential receptors would be less than the 25 mrem/yr criterion in all SUs. Specifically, the dose ranges were calculated as follows:

- < 0.1 to 0.8 mrem/yr for the facility worker
- 0.5 to 19.8 mrem/yr for the utility worker
- all < 0.1 mrem/yr for the demolition worker
- < 0.1 to 3.4 mrem/yr for the dismantlement worker
- all < 0.1 mrem/yr for the recycle worker
- all < 0.1 mrem/yr for the off-site resident

The maximum exposed individual (utility worker) received an average estimated dose of 8.3 mrem/yr assuming he/she splits time equally between Class 1 and Class 2 areas. This average result is still conservative, but represents a more realistic exposure scenario for the Madison Site. These results demonstrate that the 25 mrem/yr limit described in the ROD has been satisfied for all modeled receptors. Thus, the FUSRAP remediation of the Madison facility achieved unrestricted release based on the "average member of the critical group". The critical group is defined in 10 CFR 20.1003 as "the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances." Hence, the facility is suitable for release without radiological restrictions for MED / AEC contaminants for all future land uses which include: demolition, dismantlement and recycling of building structures. No land use controls apply.

Conclusions

The residual radioactivity at the Madison Site meets the requirements as specified in the FSS design, the data quality objectives (DQOs), and the data quality assessment (DQA). The dose-based criteria for total uranium have been satisfied, noting that no systematic or biased result exceeded the corresponding dose-based DCGL. Given that the DCGLs were shown to correspond to a dose of 25 mrem/yr, the results also show that residual dose would be less than the limit for all survey units even when considering small areas of elevated activity. All 36 SUs satisfy statistical requirements. Given that the dose-based DCGL and the statistical tests have been satisfied, all Madison Site SUs are released for unrestricted use.

Although the current and expected future land use of the Madison Site is industrial, remediation of MED / AEC contamination at the facility was required to achieve "radiological criteria for unrestricted use" as specified in 10 CFR 20.1402 without regard to future anticipated land use. Potential future land uses evaluated include continued industrial use, demolition, dismantlement and recycle of building structures, and residential development.

In conclusion, all ROD cleanup criteria for MED / AEC contaminants have been satisfied and dose assessments for potential future use scenarios meet applicable regulatory criteria. Therefore, no radiological restrictions for MED / AEC contaminants will be placed on present or potential future stakeholders regarding current or future use of the Madison Site.

1.0 INTRODUCTION

This report describes, and assess the effectiveness of the remedial action conducted as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP) at Madison, Illinois. The location of the Madison Site is shown in Figure 1. The areas impacted by past Atomic Energy Commission/Manhattan Engineer District (AEC/MED) operations were limited to Buildings 4 and 6 of the facility as shown in Figure 2, focusing specifically on interior structure surfaces in the vicinity of the extrusion press. The characterization survey performed by the United States Army Corps of Engineers (USACE) in 1998 addressed other interior surfaces in Buildings 4 and 6, including the exterior Building 6 roof, ground areas immediately outside doors of Buildings 4 and 6, surfaces of the extrusion press and adjacent equipment, and floor penetrations (pits, trenches, etc.) in the immediate vicinity of the extrusion press. Because historical site information and the results of the 1998 survey indicated that facility areas (other than those shown in Figure 2) are not impacted, a final status survey of the entire facility was not required. Uranium is the contaminant of concern (COC) for the Madison Site, specifically the isotopes uranium-238 (U-238), U-235, and U-234. The uranium used at the site was neither depleted nor enriched.

Arrowhead Contracting, Inc. was contracted by USACE as the remediation contractor for the removal of contaminated material from the Madison Site. Science Applications International Corporation (SAIC) was contracted by the USACE to prepare and implement the final status survey plan and to evaluate the final status survey results.

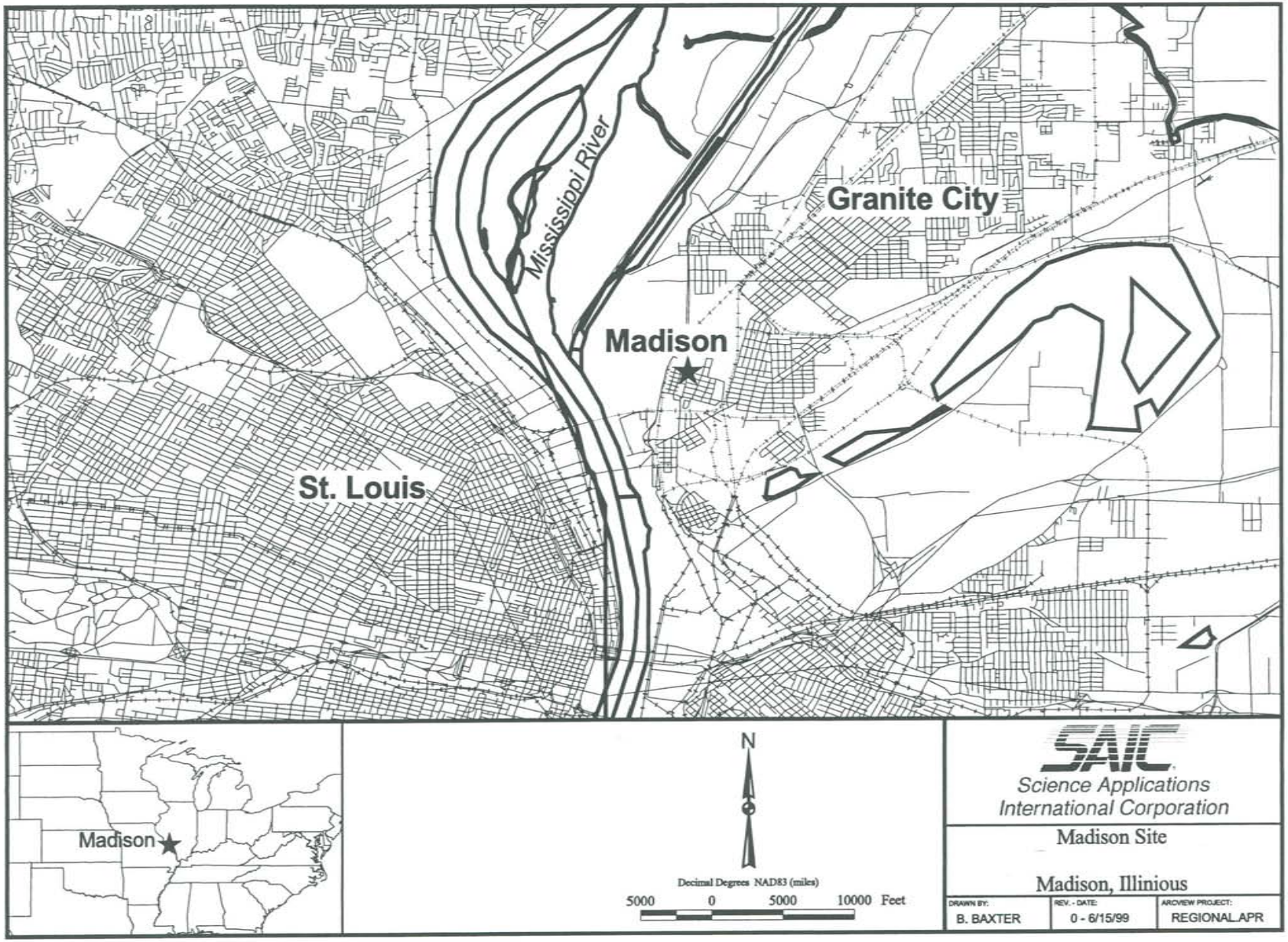


Figure 1. Location of Madison Spectrulite Consortium

2.0 SITE DESCRIPTION AND HISTORY

The Madison Site consists of a large, multi-sectional complex of 10 interconnecting buildings with a total under-roof area of about 130,000 square meters (m^2) [1.4 million square feet (ft^2)]. Building 6 is about 83-meters (m) [270-feet (ft)] wide and 303-m (1,000-ft) long. The main bay ceiling is approximately 14-m (46-ft) high, 18-m (60-ft) at the highest point along the building centerline. The building structure consists of steel columns on approximately 7.6-m (25-ft) centers, connected by trusses and multiple smaller vertical and horizontal cross members. Walls are concrete block with some brick veneer. Floors are concrete; with rough and pitted surfaces. Much of the floor in the vicinity of the extrusion press is covered with a thin layer of oily dirt and fine metal debris.

The Madison Site located in Madison, Illinois, (see Figures 1 and 2) was used to perform extrusions of uranium metal and straightening of extruded uranium rods for the AEC, the predecessor agency of the Department of Energy (DOE), during the late 1950s and early 1960s. The Dow Metal Products Division of Dow Chemical Company (Dow) conducted this work under subcontract to the Uranium Division of the Mallinckrodt Chemical Works (Mallinckrodt). The work was conducted in Building 6, a large multi-story metal building with a concrete floor. The adjoining Building 4 was used for material transfers. The AEC-funded research was conducted at the plant to determine what factors in the extrusion of uranium metal affected the selection of tools and auxiliary supplies to be used at a planned extrusion press to be located at another AEC production facility. The work included researching properties of various die metals, the contour of the die cavity, the nature of the lubricant to apply to the uranium metal, the composition of the "follower block" (the material placed between the uranium metal and the ram press), and the speed at which the metal could be extruded. At least two rod-straightening campaigns occurred at the Madison Site. Records suggest a small quantity of uranium was involved in these operations. Mallinckrodt retained accountability for the uranium throughout the operations and was responsible for removing unused uranium and for cleanup of facilities following operations. The AEC-funded operations resulted in residual radiological contamination in dust on overhead steel beams in the plant.

In the Designation Summary for the Former Dow Chemical Company Site in Madison, Illinois (ORNL, 1990), the Department of Energy indicated that Dow also supplied materials (chemicals, induction equipment, and magnesium metal products) and services under purchase orders issued by Mallinckrodt. In March 1960, the Uranium Division of Mallinckrodt Chemical Works issued a purchase order for Dow to straighten Mallinckrodt-supplied uranium rods. Two rod-straightening campaigns were identified in the purchase order. One was to be completed on December 21, 1959, the second on January 25, 1960. Each campaign also included a cost for the cleanup of the area after each campaign. The actual periods of performance for this work and the actual quantity of uranium that was processed are unknown. However, the total value of the purchase order and the unit cost identified with the "lot size" indicates that the quantity of metal involved was most likely small. DOE indicated that no other operation or period of involvement with the processing or handling of FUSRAP related material at the Madison Site has been discovered.

Dow leased the Madison facility to Phelps Dodge Aluminum Corporation in 1969. Consolidated Aluminum Corporation assumed the lease in 1973 and exercised an option to buy the plant in 1973. Consolidated Aluminum Corporation processed magnesium thorium alloys at the Madison Site. Consolidated Aluminum Corporation sold the Madison plant to Barnes Acquisition, Inc. [which appears to have been a subsidiary of the Spectrulite Consortium, Inc. (Spectrulite)] in September 1986. Although Spectrulite (the current operator of the facility) has also processed magnesium-thorium alloys at the site, these operations are beyond the scope of FUSRAP remedial actions and this document.

3.0 REMEDIAL ACTION GUIDELINES

The remedial action guidelines for the remediation of the Madison Site were established in the Record of Decision (ROD) (USACE, 2000b). Specifically, the ROD established guidelines for satisfying the 25 millirem per year (mrem/yr) dose limit as described in the Code of Federal Regulations (CFR) Title 10 Part 20 Subpart E. Conservative dose calculations using site-specific information indicate that the derived concentration guideline level (DCGL) for surface contamination is 6000 disintegrations per minute (dpm) per 100 cm^2 and the volumetric (dust) DCGL is 20 pCi/g of total uranium (U-238 plus U-235 plus U-234). These DCGLs will satisfy the 25 mrem/yr dose criterion. DCGLs for the Madison Site are listed in Table 1. A volumetric limit of 300 pCi/g (also corresponding to the 25 mrem/yr dose criterion) has also been established for the difficult-to-access overhead surfaces. To assure that remedial and final status survey activities satisfy the 25 mrem/yr criterion, the *Final Status Survey Plan for the Madison FUSRAP Site – Madison, Illinois* (FSSP) (USACE, 2000c) evaluated data using the following six questions:

- Is the radiological COC below the 6000 dpm/100 cm^2 limit on Class 1 overhead surfaces and Class 2 and 3 building and equipment surfaces?
- Is the radiological COC below the 20 pCi/g limit in accumulated dust on Class 2 and Class 3 overhead surfaces?
- Is the radiological COC below the 300 pCi/g limit in accumulated dust on the difficult-to-access overhead surfaces?
- Do small areas of elevated radioactivity produce utility worker doses less than 25 mrem/yr?
- Is the residual dose to the modeled utility worker ≤ 25 mrem/yr?
- Do surface contamination sample/measurement results satisfy the Wilcoxon Rank Sum (WRS) statistical test as described in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)?

If the answer to any one of these questions had been "no" for any survey unit (SU), cleanup goals are not satisfied for that SU and the remediation contractor would be required to remove additional building and/or equipment surface contamination and reevaluate the affected survey unit.

Table 1. Madison Site DCGLs

Measurement	DCGL*
Total U (surface criteria)	6000 dpm/100 cm^2 (Beta)
Total U (volumetric criteria)	20 pCi/g
Dose	25 mrem/yr

* Concentration limits of 300 pCi/g total uranium also set for difficult-to-access areas.

4.0 REMEDIAL ACTION SUMMARY

Remediation of the impacted Class 1 areas at the Madison Site involved the removal of radioactively contaminated dust from accessible overhead surfaces (horizontal surfaces including window ledges, utility conduits, trusses and cross member beams at heights of approximately 25 to 36 ft). Decontamination techniques included vacuuming with HEPA filtered vacuums, and scraping and vacuuming. Occasionally debris was swept by hand directly into vacuum bags. More aggressive decontamination techniques included in the design were not required. Nearly 60,000 pounds of dust and debris were removed from the Class 1 areas which was shipped to a properly permitted out of state facility. The areas above the top chord of the building trusses that were difficult-to-access due to overhead obstructions and constraints of lifting devices did not require remediation because sampling results from this area demonstrated that the dust on those surfaces averaged less than the volumetric DCGL criteria applicable to these 'difficult-to-access" areas.

Dust was removed from pipe runs containing asbestos insulating materials without damaging the insulating wrap. A few small pieces of asbestos containing material were encountered on some surfaces. Due to the insignificant quantity relative to the volume of waste generated, the small pieces of asbestos containing material were vacuumed along with the dust and disposed of appropriately.

Following decontamination of the accessible overhead surfaces, the equipment and floor areas underneath the decontamination activities were surveyed. No contamination above the surficial DCGL was found.

After all of the additional areas had been remediated, the areas were subjected to final status verification surveys in accordance with the FSSP (USACE, 2000c). Results of the data assessment indicated that the remediated areas had achieved the remedial action objectives and could be released without radiological restrictions.

A detailed description of the remedial action activities is included as Appendix A of this document.

5.0 POST-REMEDIAL ACTION MEASUREMENTS

Buildings 4 and 6 were divided in accordance with MARSSIM (DoD et al. 1997) into SUs according to MARSSIM classification. Class 1 SUs were those that had radioactive contamination above the DCGL prior to remediation. Class 2 SUs were those that had a potential for radioactive contamination above the DCGL due to its proximity to Class 1 areas, but are not expected to exceed the guideline. Class 3 SUs were those not expected to contain residual activity or those expected to contain levels of residual radioactivity at a small fraction of the DCGL. The SUs were originally defined as prescribed by the FSSP. Some minor adjustments were made during the final status surveys when contamination above the volumetric DCGL was discovered in Class 2 areas as shown in Table 2.

Table 2. Survey Unit Descriptions

SU No. (Final)	SU No. (Original)	Class	Description
1 through 8	1 through 8	1	Class 1 at 25-ft level. Compare data to 6000 dpm/100 cm^2.
9	9	2	Class 2 at 25-ft level. Compare data to 20 pCi/g.
11 through 15	10 through 14	1	Class 1 at 36-ft level. Compare data to 6000 dpm/100 cm^2.
16	16	2	Class 2 at 36-ft level. Compare data to 20 pCi/g.
17 through 27	17 through 27	2	Class 2 floors. Compare data to 6000 dpm/100 cm^2.
28 and 29	28 and 29	2	Class 2 equipment. Compare data to 6000 dpm/100 cm^2.
30	30	3	Class 3 overheads. Compare data to 20 pCi/g.
31	31	3	Class 3 walls. Compare data to 6000 dpm/100 cm^2.
32	32	3	Class 3 floors. Compare data to 6000 dpm/100 cm^2.
33	32	3	Class 3 equipment. Compare data to 6000 dpm/100 cm^2.
34	Part of 9	1	Originally part of Class 2 SU-9. Renumbered to Class 1 SU-34 due to uranium concentrations in dust > 20 pCi/g. Compare data to 6000 dpm/100 cm^2.
35	Part of 9	1	Originally part of Class 2 SU-9. Renumbered to Class 1 SU-35 due to uranium concentrations in dust > 20 pCi/g. Compare data to 6000 dpm/100 cm^2.
36	15	1	Renumbered in field. Compare data to 6000 dpm/100 cm^2.
37	Part of 16	1	Originally part of Class 2 SU-16. Renumbered to Class 1 SU-37 due to uranium concentrations in dust > 20 pCi/g. Compare data to 6000 dpm/100 cm^2.

MARSSIM guidance for structures was followed for walls and floors. The concern at the Madison Site was primarily contamination on the horizontal surfaces of overhead structural members including trusses, cross members, braces, sag rods, I-beam roof supports, pipe runs, and window ledges which do not fit readily into the MARSSIM framework.

The boundaries of the Class 1 SUs were selected to ensure that the horizontal surfaces of the main structural beams represented approximately 100 m^2 or less of the total surface area of any Class 1 unit. The truss "V" sections, cross members and bracing may add up to an additional 100 m^2 to each survey unit. Class 1 and 2 survey units were defined for the horizontal overhead

structures at the 25 and 36 ft levels (Figures 3 - 4A). None of the Class 1 SUs exceeded 200 m^2 total horizontal surface area.

Additional Class 2 SUs, illustrated in Figures 5 and 6, were defined for the equipment and floor beneath the Class 1 overhead structures scheduled for remediation. The Class 2 units were set at approximately 1000 m^2 or less rounded to 2 significant figures.

The remainder of the overhead structure surfaces, floor area, equipment, and walls in Buildings 4 and 6 were classified as Class 3 SUs.

Five types of measurements were made during the final status survey to determine whether the remedial action had met the applicable DCGL. These consisted of:

1. Surface beta scans to identify potential locations of elevated activity;
2. Fixed point measurements of total beta surface activity;
3. Fixed point measurements of total gamma dose rate;
4. Sampling of surface dust and residue;
5. Discrete measurements of removable alpha and beta surface activity.

Of these, the fixed point beta measurements (item 2) and dust/residue samples (item 4) were used to compare against the 6000 dpm/100 cm^2 and 20/300 pCi/g criteria, respectively. The other measurements were taken for completeness and to assess residual dose following completion of remedial activities, as necessary. Areas that contained residual contamination above the DCGLs listed in Table 1 were investigated and remediated, as appropriate. Figures 3 through 10 show sample/measurement locations for all SUs. Figure 11 shows sample locations for the difficult-to-access areas.

5.1 SURFACE BETA SCANS

Processed natural uranium has associated alpha, gamma and beta radiations, which can be used to identify the presence of residual contamination and estimate the concentrations potentially present at the Madison Site. Surface scans for gross beta radiation will be performed to identify locations of elevated residual radiological contamination. Beta scans are being used because alpha radiation is a less reliable indicator of true surface activity levels due to greater attenuation (Abelquist, 1997).

Screening beta scans were performed over 100% of accessible Class 1 SUs, 10 to 50% of accessible Class 2 SUs, and 10 to 20% of accessible Class 3 SUs. Locations identified during the surface scans that exceeded the investigation level were investigated by taking fixed point measurements to confirm and quantify contaminant levels in the area of elevated activity. The investigation levels were set to 67% of the DCGL, or 4,000 dpm/100 cm^2 for surficial contamination except for the Class 2 and 3 overhead areas. The Class 2 and 3 overhead area investigation level was set to 480 dpm/100 cm^2, corresponding to 20 pCi/g total uranium for dust-laden surfaces (USACE, 2000c). The field radiation detection survey instruments (and their

functional and performance specifications) used during the surveys are listed in Table 3. Detection sensitivities were determined following the guidance of NUREG-1507 (NRC, 1998).

Table 3. Radiological Field Survey Instruments

Description	Application	Scan MDC (dpm/100 cm^2)
Ludlum Model 2350-1 coupled with a Ludlum 43-37 (floor monitor). Effective area 545 cm^2.	Beta surface scan and fixed point measurements on concrete floor surfaces.	1500 at 3 inches per second
Ludlum Model 2350-1 coupled with a Ludlum 43-106 (gas flow proportional counter). Effective area 126 cm^2.	Beta surface scan and fixed point measurements on dust covered steel surfaces.	430 at 1 inch per second
	Beta surface scan and fixed point measurements equipment surfaces.	900 at 2 inches per second
	Beta surface scan and fixed point measurements on concrete and cinder block surfaces.	2500 at 2 inches per second
Ludlum Model 2360 coupled with a Ludlum 43-89 (ZnS plastic scintillator). Effective area 126 cm^2.	Beta surface scan on remediated steel and equipment surfaces.	1300 at 2 inches per second
Ludlum Model 2929 bench scaler coupled with a Ludlum 43-10 (ZnS plastic scintillator).	Removable activity on smear samples taken on various surfaces.	14 with a 1-minute sample count time.

5.2 TOTAL BETA SURFACE ACTIVITY

Total beta surface activity (fixed point) measurements were taken in a systematic sampling pattern. The measurements were used to demonstrate whether each SU satisfied the site DCGL. Ten samples were taken in each survey unit based on the MARRSIM procedure for calculating the number of samples required for the 95% confidence limit. The standard deviation used for the calculation (pre-remediation) was obtained from Remedial Investigation (RI) data (USACE, 2000a). Total beta surface activity measurements were used to evaluate final status over relatively dust-free surfaces, therefore excluding Class 2 and Class 3.

Instead of a triangular or rectangular grid, sample spacing was determined based on the total linear length of horizontal beam in the survey unit. For a typical Class 2 SU, the beam length between samples was about 10.7 m. A similar approach was taken in Class 1 units. Class 3 sample locations were selected using a random number generator.

5.3 REMOVABLE ALPHA AND BETA SURFACE ACTIVITY

Smear samples were taken at the same sample locations as the fixed-point surface measurements by wiping a 100-cm^2 area with dry filter paper. The smear samples were analyzed for alpha and beta activity using a Ludlum 2929 bench scaler coupled with a ZnS plastic scintillation detector.

5.4 SURFACE DUST AND RESIDUE SAMPLES

Samples of surface dust and residue were collected from horizontal surfaces of overhead Class 2 and Class 3 survey units for comparison with the volumetric cleanup criteria (dust and residue were removed from the Class 1 units during the remedial activities). Dust and residue samples were collected, packaged and uniquely identified in accordance with chain-of-custody and site-specific procedures and transported to the USACE-certified radioanalytical laboratory for isotopic uranium analysis. Sample locations are shown in Figures 3, 4, and 7. Surface dust samples were also collected in difficult-to-access overhead areas. Sample locations for the difficult-to-access overhead areas are shown in Figure 11.

5.5 QUALITY ASSURANCE AND QUALITY CONTROL

Precision and accuracy are determined by the analysis of field duplicate samples and split samples. Precision is measured by comparing the analytical results of the field duplicates, which are samples taken at the same location as the sample they duplicate and analyzed in the same laboratory. Accuracy is measured by comparing the results of the split samples, which are aliquots of samples analyzed by a separate laboratory. Severn Trent Laboratories analyzed the split samples. The DQOs established for this Final Status Survey requires that about 1 in 20 of the surface measurements and samples should be duplicated. A total of five duplicates were obtained out of 97 samples collected during the final status survey. The results are shown in Table 4. The objectives set by the FSSP were to achieve a relative percent difference between duplicate sample and split sample analyses of 30% or less within the statistical counting error for values determined at 50% of the criterion value when the reported activities are greater than 5 times their minimum detectable activities (MDAs). Measurements determined at levels below 5 times their respective MDA were considered acceptable if the normalized absolute difference was less than 1.96. The precision and accuracy of the final status survey sample analyses are acceptable and the data are useable for their intended purpose. The detailed results of the quality control analysis for Madison Site data are provided in Appendix C, Madison Site Final Status Survey Quality Control Summary Report.

Table 4. Duplicate Dust Sample Results

Parent ID/Duplicate ID	Th-228		Th-230		Th-232		U-234		U-235		U-238	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
MAD00074/MAD0074-1	-	-	-	-	-	-	-	1.28	NC	1.02	-	1.38
MAD00076/MAD0076-1	-	-	-	-	-	-	-	1.14	29.3%	-	16.7%	-
MAD00086/MAD0086-1	-	-	-	-	-	-	-	1.10	-	0.82	-	0.88
MAD00239/MAD00239-1	12.2%	-	26.1%	-	21.6%	-	-	0.95	NC	0.38	21.1%	-
MAD00519/MAD00519-1	9.7%	-	-	0.79	-	0.51	-	**2.35**	NC	1.49	9.0%	-

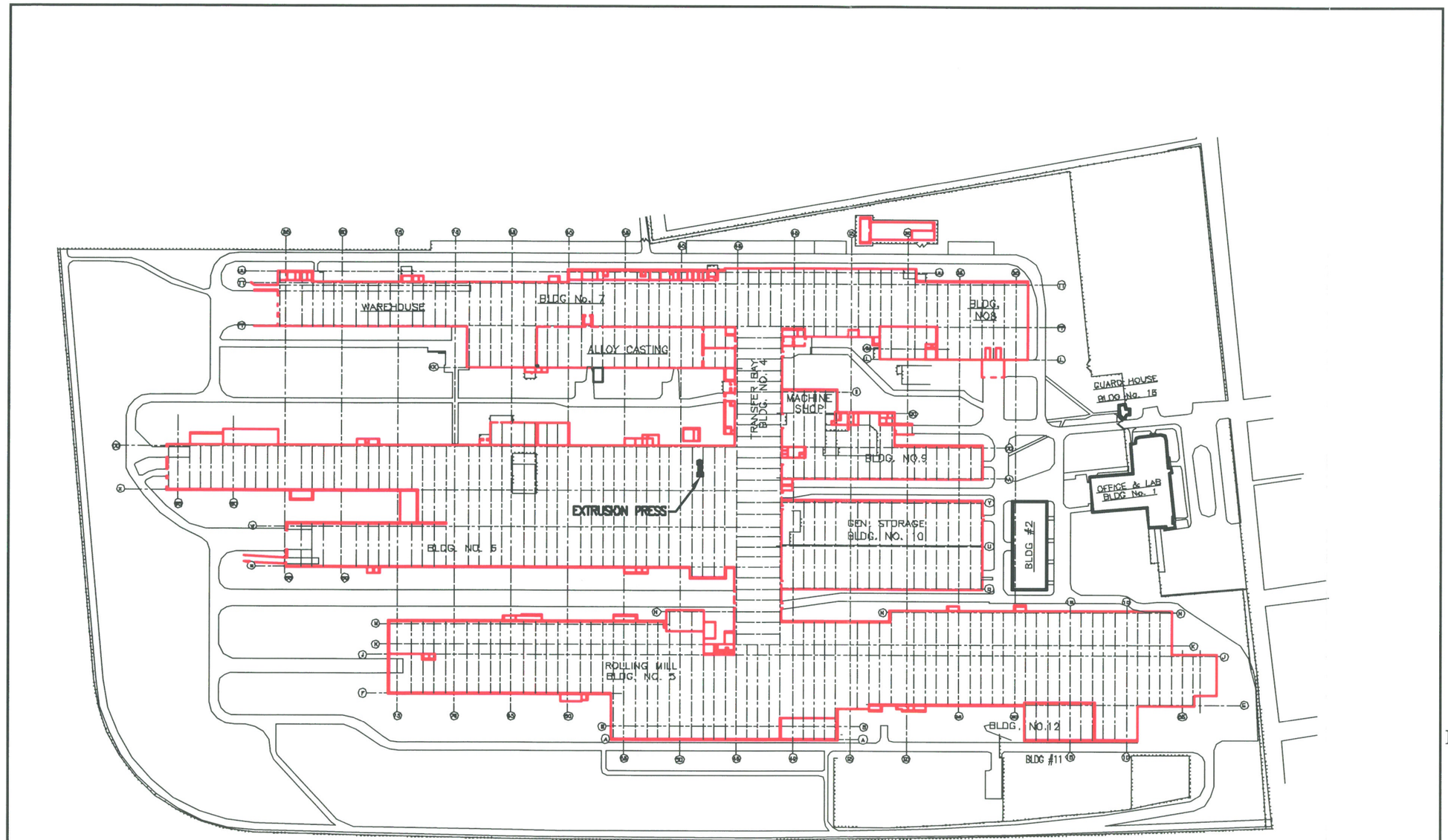
5.6 SAMPLE ANALYSIS

Dust/residue samples were transferred to the USACE-certified radioanalytical laboratory for analysis in accordance with documented laboratory-specific standard methods and the FUSRAP Sampling and Analysis Guide. Each sample was subjected to isotopic uranium analysis by alpha spectrometry (dust and residue samples). In accordance with MARSSIM, analytical techniques provided a minimum detection level of 10% of the remedial action guideline (i.e., 2 pCi/g total uranium).

Smear samples were counted with a Ludlum 2929 bench scaler coupled with a ZnS plastic scintillation detector.

5.7 DATA EVALUATION

The evaluation of final status sample data is presented in Appendix B, the Data Quality Assessment. Where additional remediation was performed, based on survey or sampling results, scans and sampling of the newly remediated area were repeated. None of the systematic or biased samples included in the final status survey data set exceeded the cleanup criteria presented in Table 1. Consequently, no statistical analysis to demonstrate compliance with cleanup criteria was necessary.



LEGEND:

- ROAD
- WALLS
- FENCE
- WALKWAY
- BUILDINGS
- COLUMN LINE

0 20 40 60 80

SCALE: 1" = 76.2 METERS

0 125 250 500

SCALE: 1" = 250'

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Madison Site
Post Remedial Action Report
Madison, Illinois

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0	S. Kitchings	S. Pressly	1/31/00
1	F. Bower	S. Pressly	6/28/00

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Figure 2. Plan View of the Madison Site

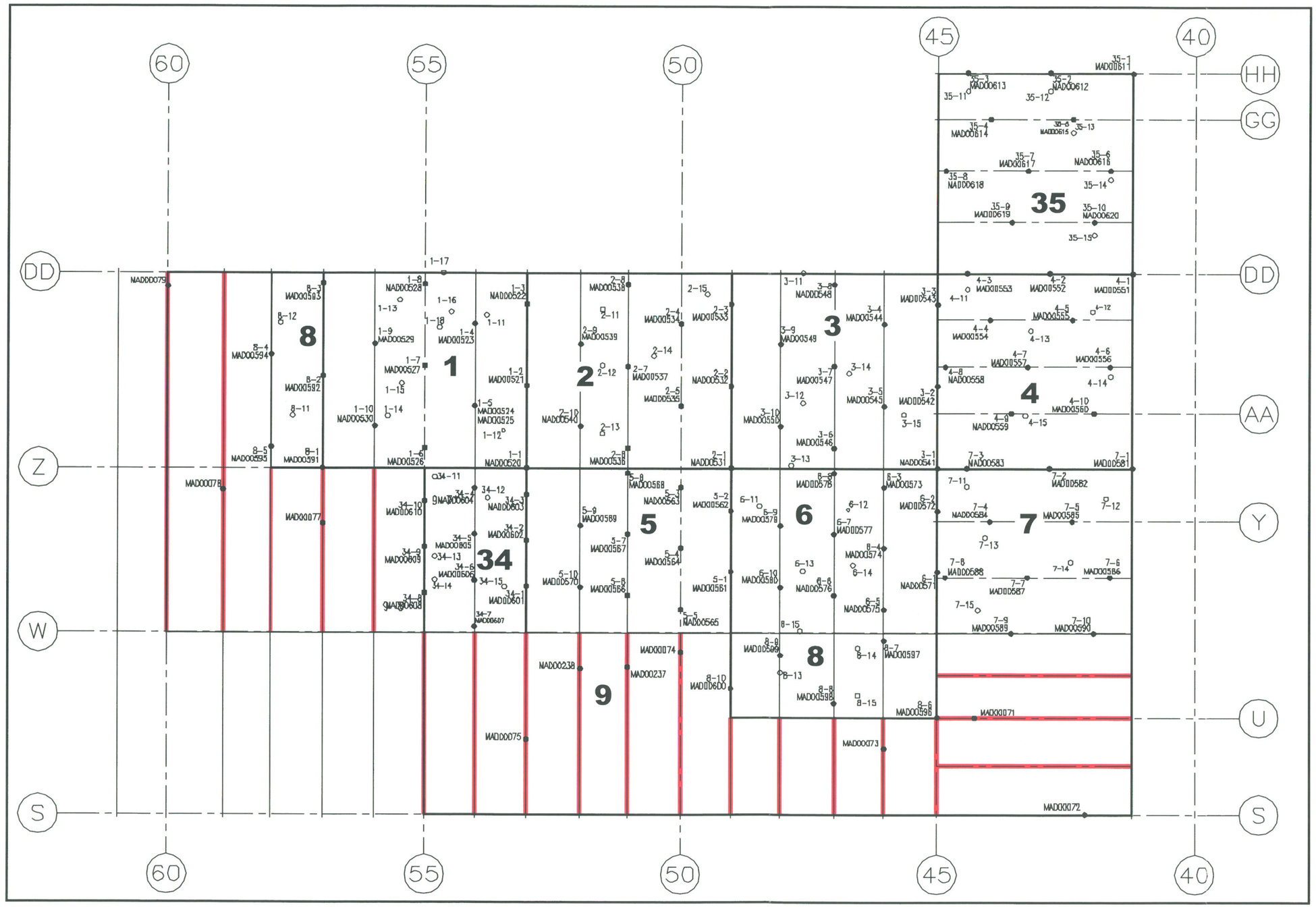


Figure 3. Class 1 and Class 2 Survey Unit Measruements at the 25 Foot Level

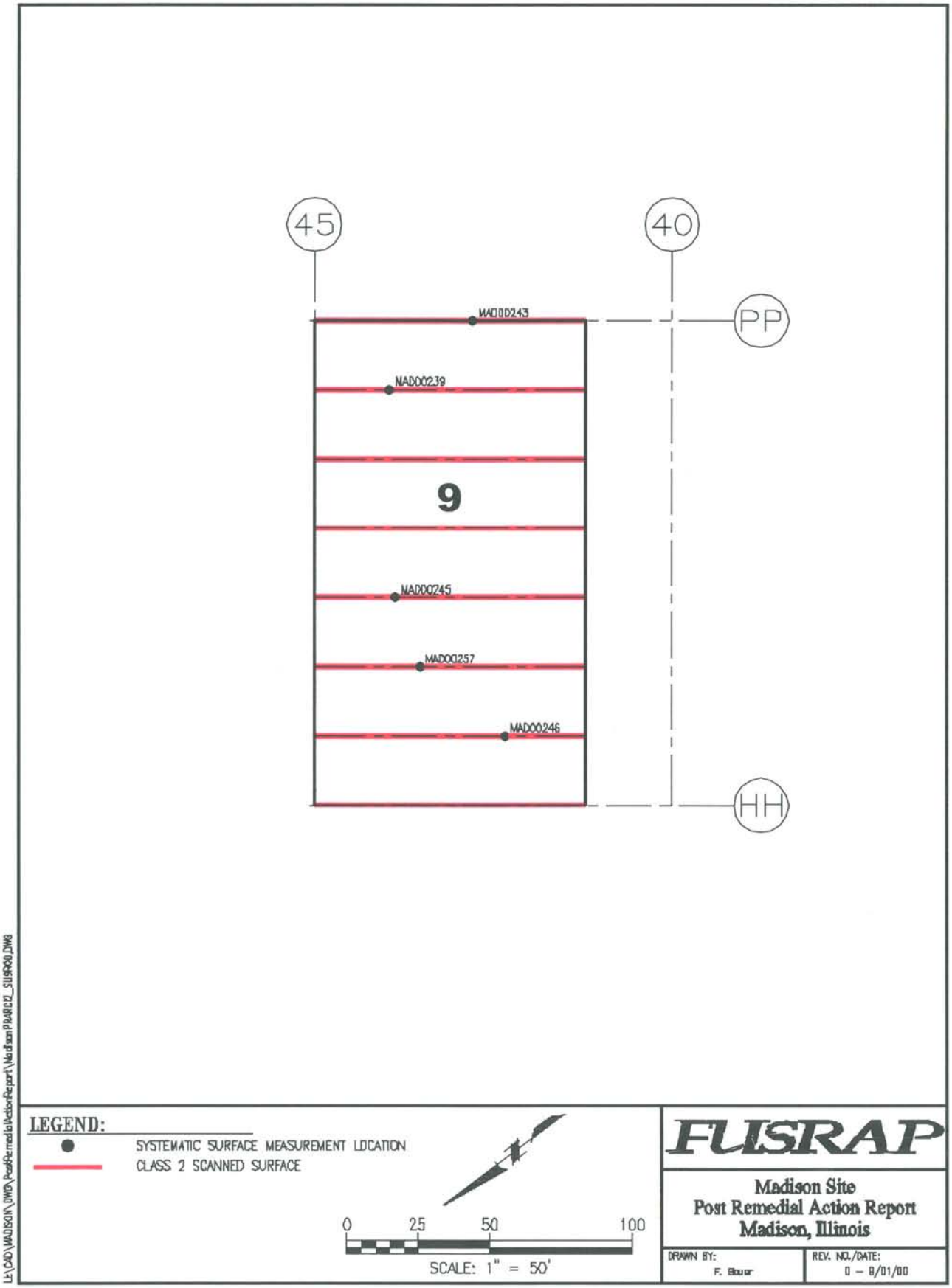
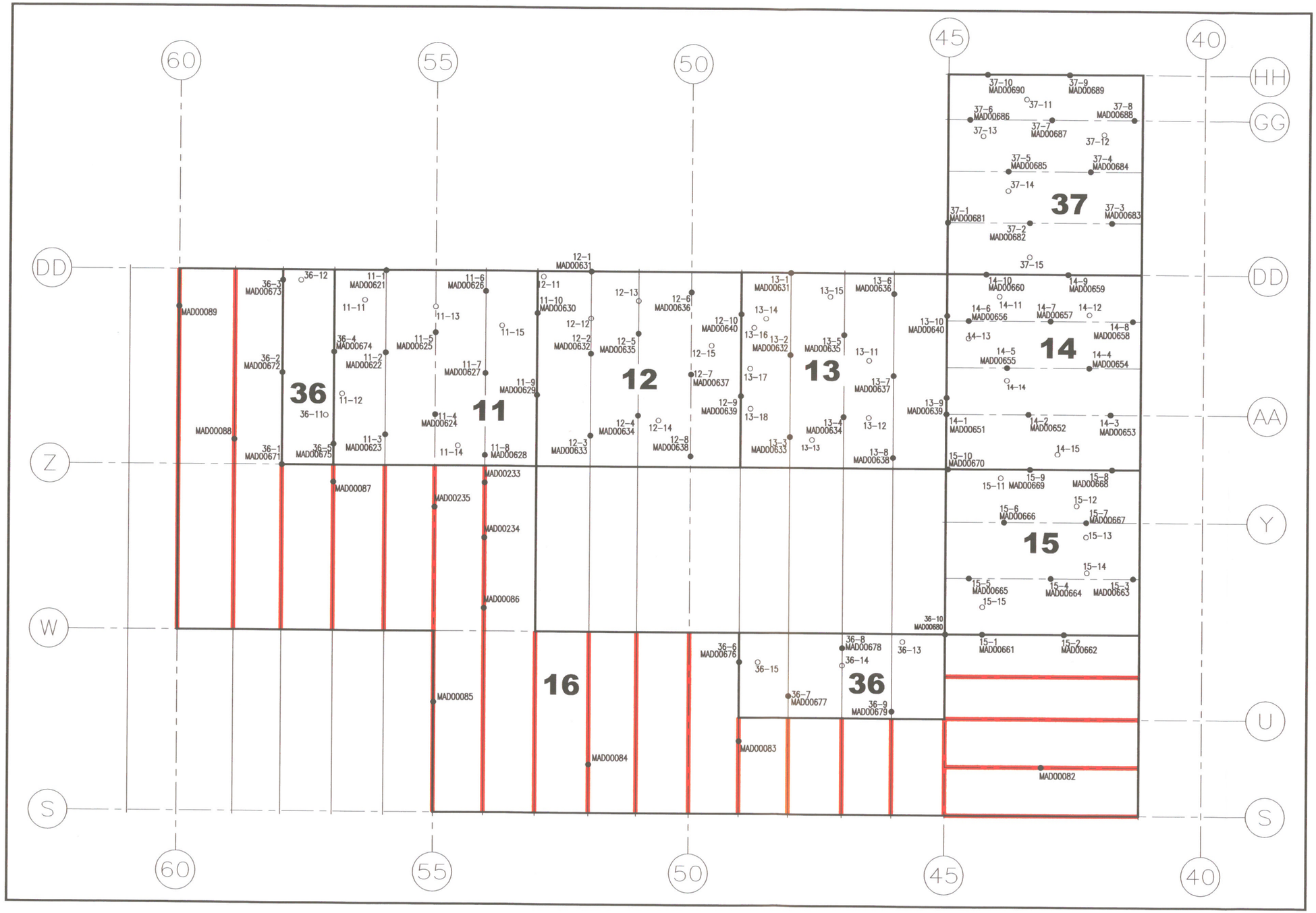


Figure 3a. Class 2 Overhead S.U. 9 Measurements



LEGEND:

- WALLS
- COLUMN LINE
- SYSTEMATIC SURFACE MEASUREMENT LOCATION
- CLASS 2 SCANNED SURFACE
- (45) COLUMN DESIGNATOR

NOTES:
All surface area from columns 45–53 in the middle bay (Z–W) are included in Survey Units 5 and 6 as shown in Figure 3 due to the smaller surface area in the middle bay as compared to the outer bays.

0 5 10 15
SCALE: 1" ≈ 15.2 METERS

0 25 50 100
SCALE: 1" = 50'

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1	F. Bauer	S. Passig	9/20/00

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Figure 4. Class 1 and Class 2 Survey Unit Measurements at the 36 Foot Level

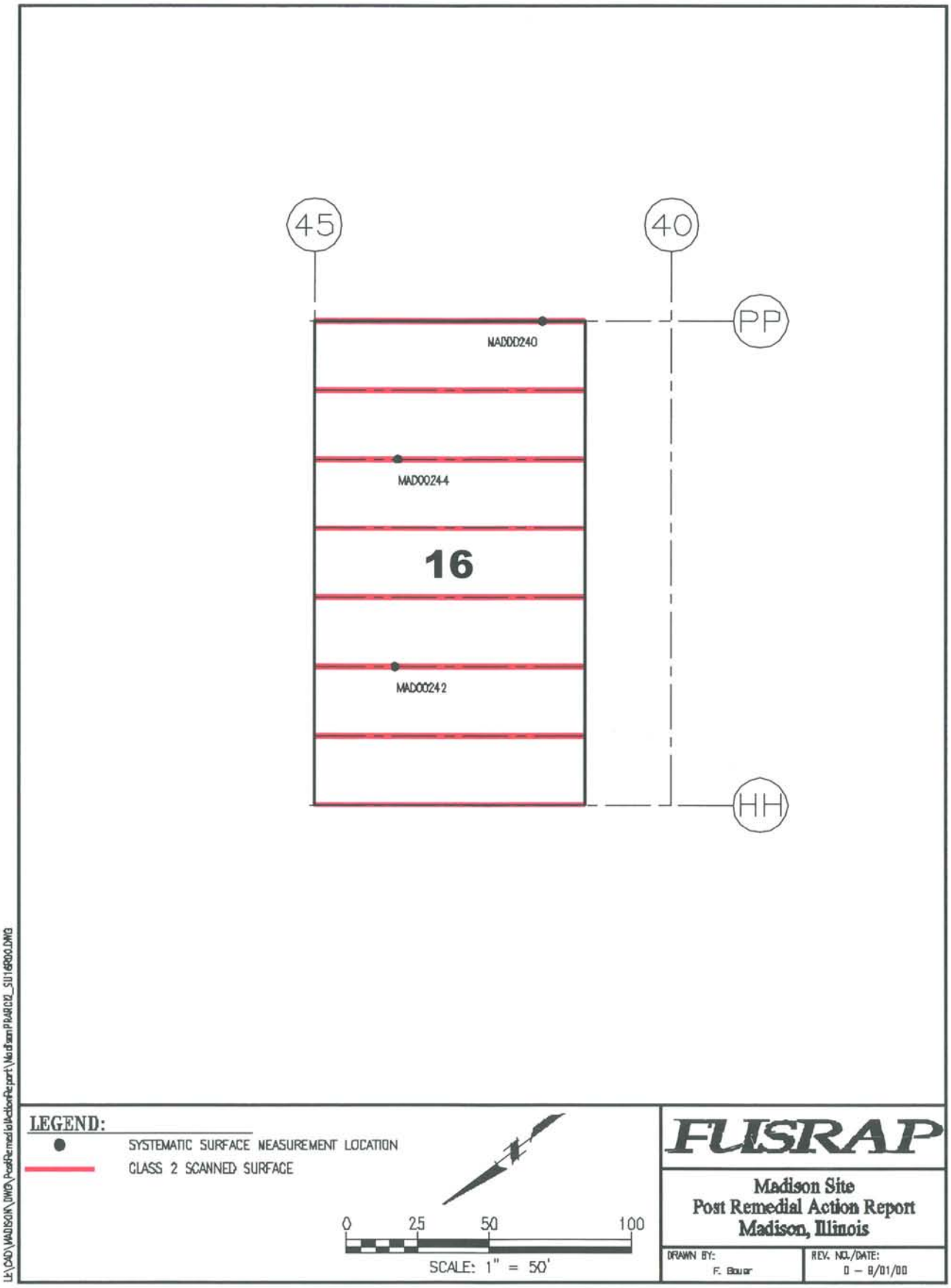
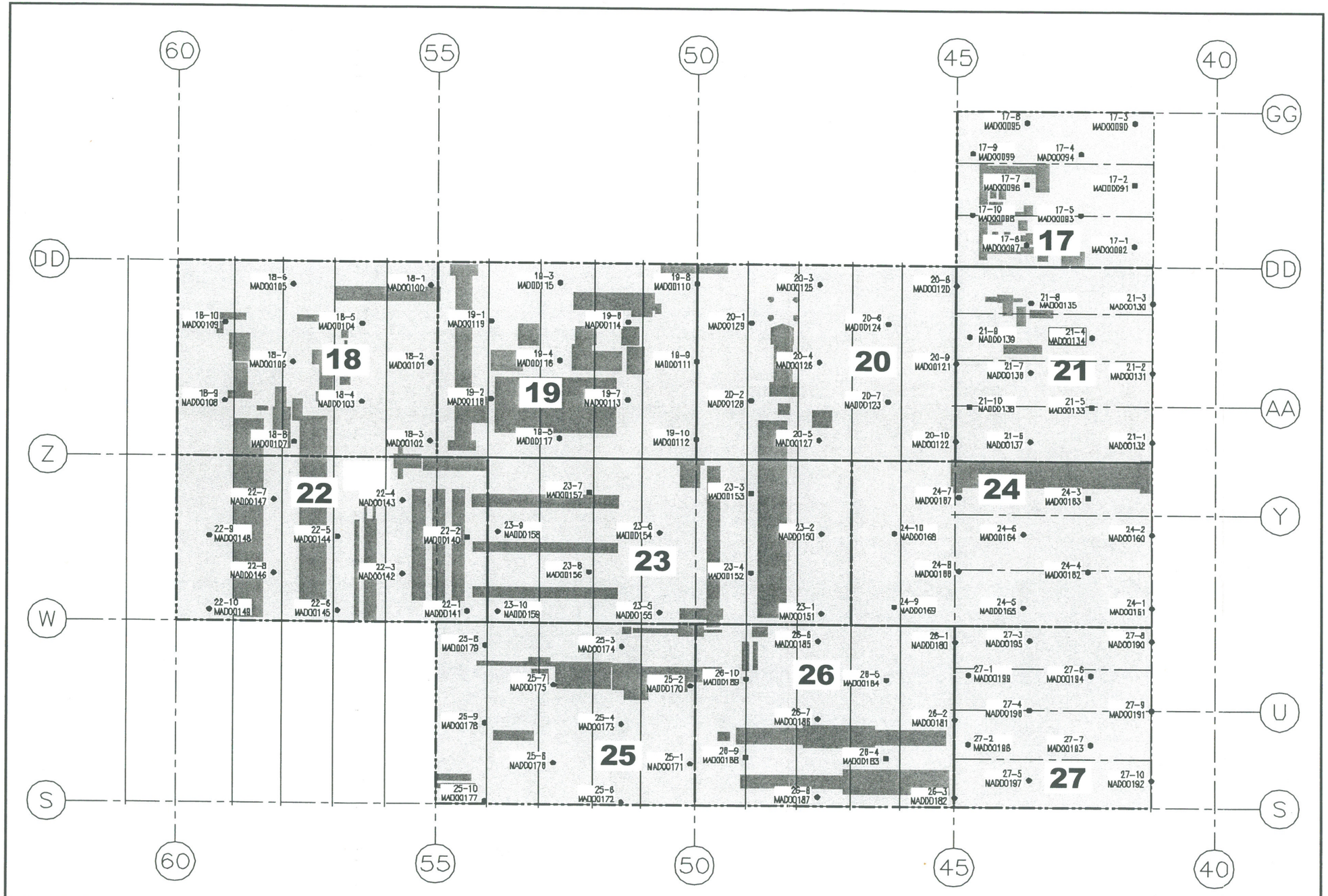


Figure 4a. Class 2 Overhead Survey Unit 16 Measurements



LEGEND:

- WALLS
- COLUMN LINE
- SYSTEMATIC SURFACE MEASUREMENT LOCATION
- EQUIPMENT

APPROXIMATELY 50% OF THE FLOOR SURFACES AROUND THE EQUIPMENT WERE SCANNED.

0 5 10 15
SCALE: 1" ≈ 15.2 METERS

0 25 50 100
SCALE: 1" = 50'

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1	F. Bauer	B. Pooley	8/23/00

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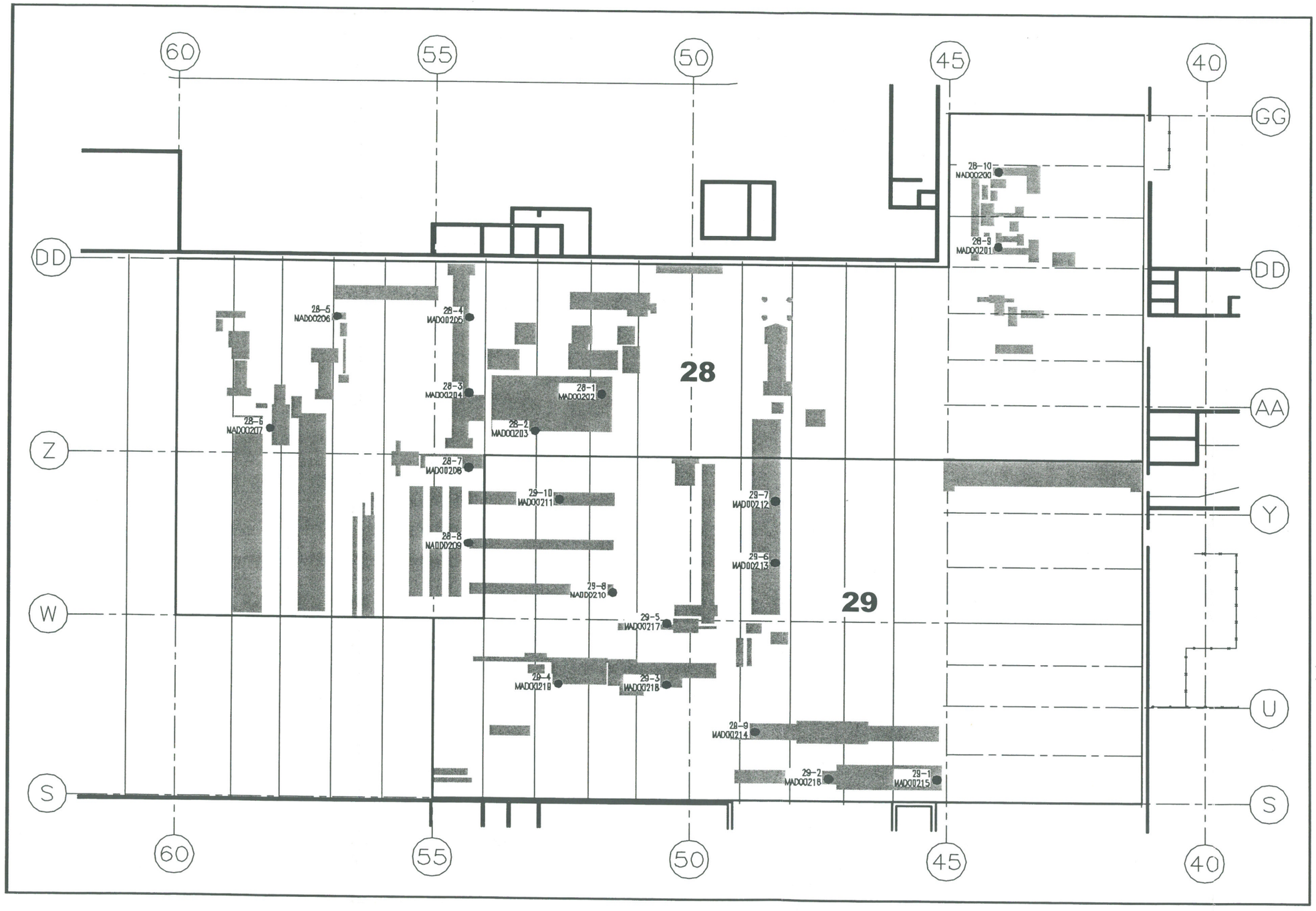
Figure 5. Class 2 Floor Survey Unit Measurements



LEGEND:

- WALLS
- COLUMN LINE
- SYSTEMATIC SURFACE MEASUREMENT LOCATION
- EQUIPMENT APPROXIMATELY 10% TO 50% OF THE EQUIPMENT SURFACES WERE SCANNED

0 5 10 15
SCALE: 1" ≈ 15.2 METERS

0 25 50 100
SCALE: 1" = 50'

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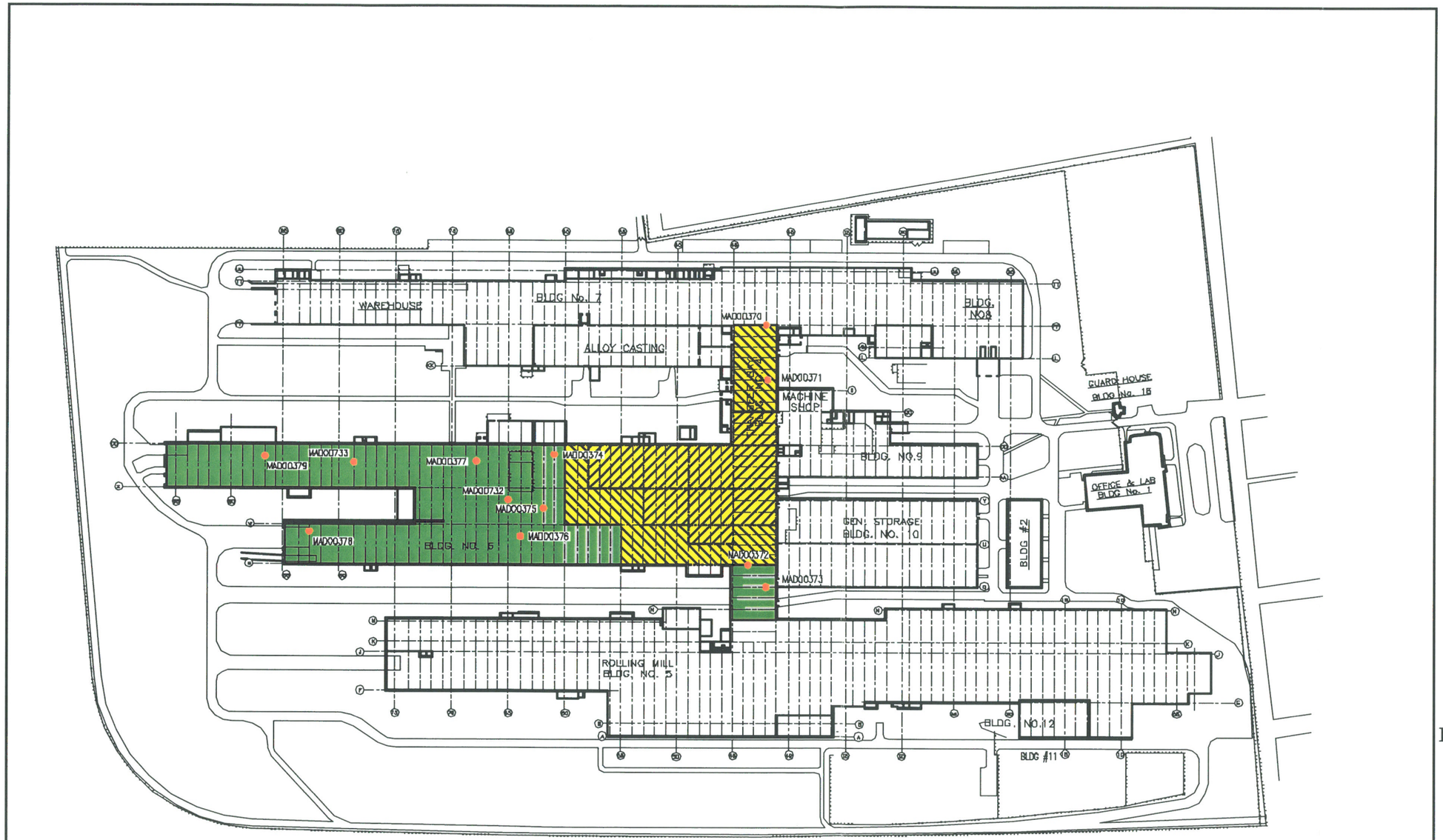
Figure 6. Class 2 Equipment Survey Unit Measurements



LEGEND:

- WALLS
- BUILDINGS
- COLUMN LINE
- CLASS 2 SURVEY UNITS AT FLOOR LEVEL
- CLASS 3 SURVEY UNITS AT FLOOR LEVEL
- CLASS 1 SURVEY UNITS AT 25 & 36 FEET LEVELS
- CLASS 2 SURVEY UNITS AT 25 & 36 FEET LEVELS
- CLASS 3 BEAN SAMPLE LOCATIONS
- CLASS 2 SCANS AT 25 AND 36 FOOT LEVELS

0 20 40 60 80
SCALE: 1" = 76.2 METERS

0 125 250 500
SCALE: 1" = 250'

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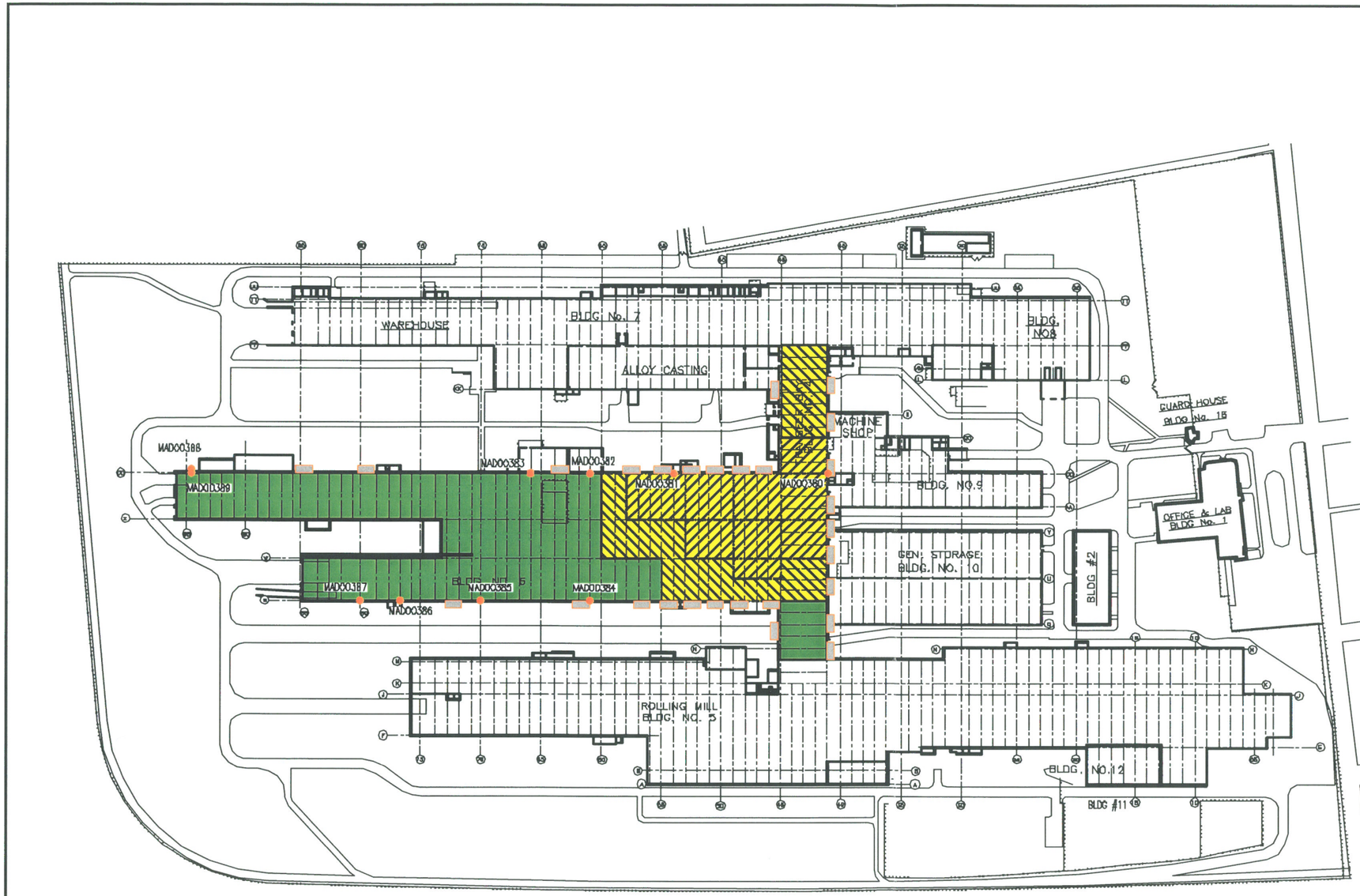
Figure 7. Class 3 Overhead Survey Unit Measurements



LEGEND:

- WALLS
- BUILDINGS
- COLUMN LINE
- CLASS 2 SURVEY UNITS AT FLOOR LEVEL
- CLASS 3 SURVEY UNITS AT FLOOR LEVEL
- CLASS 1 SURVEY UNITS AT 25 & 36 FEET LEVELS
- CLASS 2 SURVEY UNITS AT 25 & 36 FEET LEVELS
- SYSTEMATIC SURFACE MEASUREMENT LOCATION
- SCANNED AREAS

0 20 40 60 80

SCALE: 1" = 76.2 METERS

0 125 250 500

SCALE: 1" = 250'

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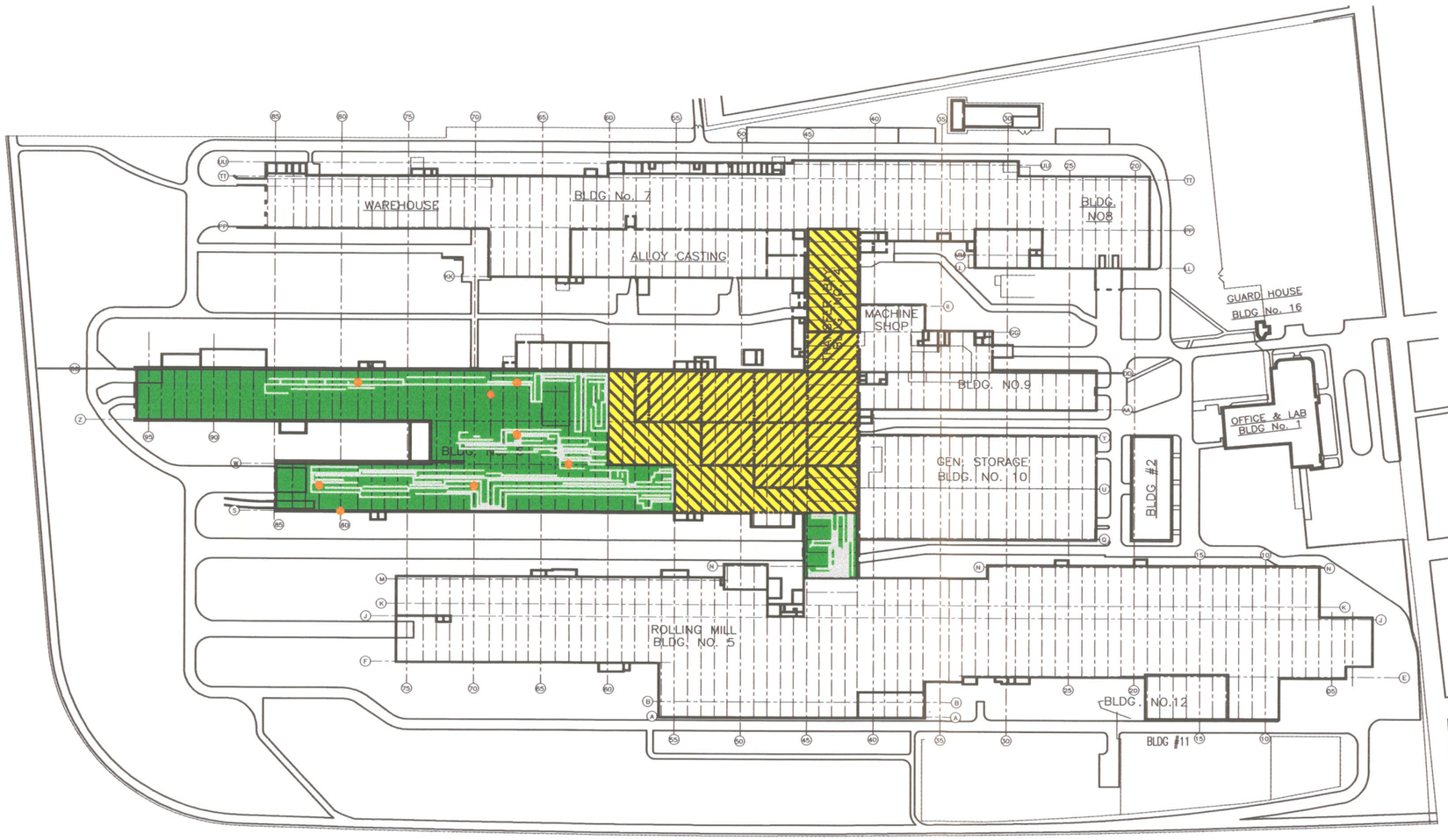
Figure 8. Class 3 Wall Survey Unit Measurements



LEGEND:

- ROAD
- WALLS
- FENCE
- WALKWAY
- BUILDINGS
- COLUMN LINE
- CLASS 2 SURVEY UNITS AT FLOOR LEVEL
- CLASS 3 SURVEY UNITS AT FLOOR LEVEL
- CLASS 1 SURVEY UNITS AT 25 & 36 FEET LEVELS
- CLASS 2 SURVEY UNITS AT 25 & 36 FEET LEVELS
- CLASS 3 SAMPLE LOCATIONS
- CLASS 3 FLOOR SCAN
- 45 COLUMN DESIGNATOR

0 20 40 60 80
SCALE: 1"≈ 76.2 METERS

0 125 250 500
SCALE: 1" = 250'

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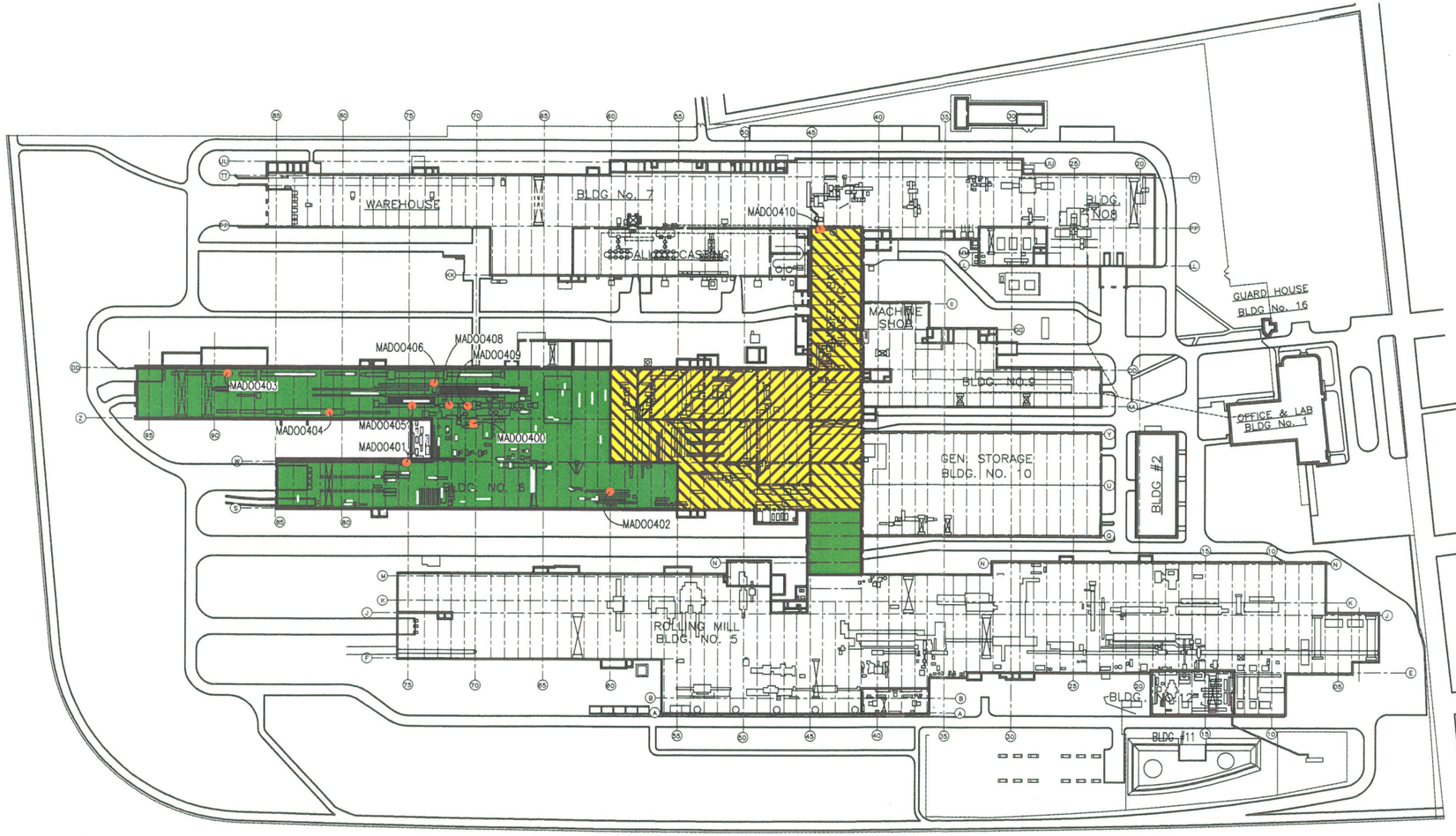
Figure 9. Class 3 Floor Survey Unit Measurements



LEGEND:

- WALLS
- BUILDINGS
- COLUMN LINE
- CLASS 2 SURVEY UNITS AT FLOOR LEVEL
- CLASS 3 SURVEY UNITS AT FLOOR LEVEL
- CLASS 1 SURVEY UNITS AT 25 & 36 FEET LEVELS
- CLASS 2 SURVEY UNITS AT 25 & 36 FEET LEVELS
- CLASS 3 EQUIPMENT SAMPLE LOCATIONS
- CLASS 3 EQUIPMENT SCAN
- (45) COLUMN DESIGNATOR

0 20 40 60 80
SCALE: 1"≈ 76.2 METERS

0 125 250 500
SCALE: 1" = 250'

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Figure 10. Class 3 Equipment Survey Unit Measurements

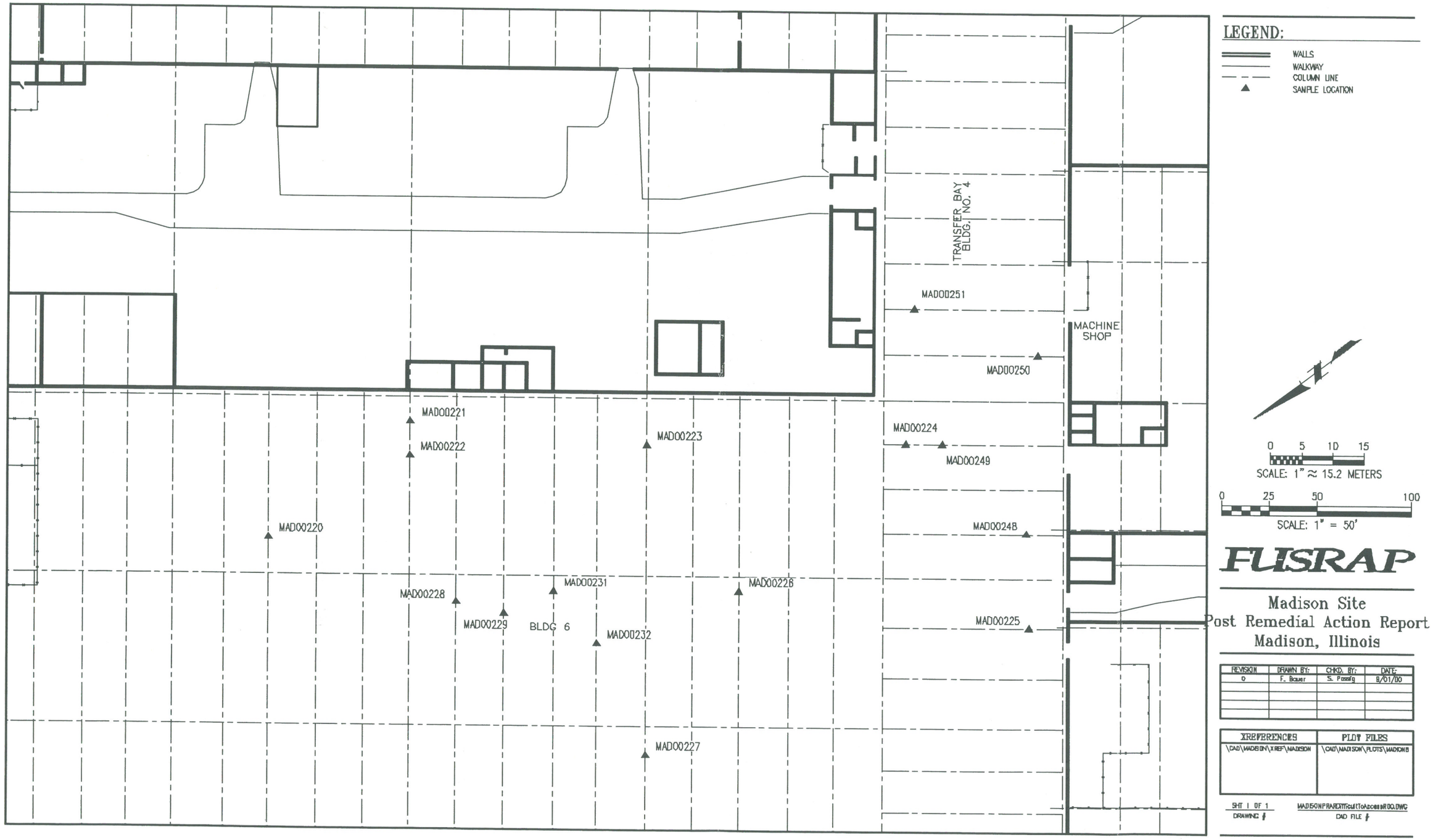

Figure 11. Difficult to Access Area Measurements

6.0 POST-REMEDIATION STATUS

6.1 FINAL STATUS SURVEY DATA

The cleanup criteria presented in the ROD are satisfied if the average concentration in a SU is less than the appropriate DCGL value listed in Table 1. The analytical results for the final status survey samples/measurements indicate that the residual radioactivity at the Madison Site meets the requirements of the remedial design and are below the dose-based guidelines. Table 5 summarizes the final status survey results for the site. The complete final status survey data set is presented in Appendix B of this report.

Table 5. Final Status Survey Data Summary

Surface Measurement Data Summary (dpm/100 cm^2)

Variable	SU-1	SU-2	SU-3	SU-4	SU-5	SU-6	SU-7	SU-8	SU-11	SU-12
Number of samples:	18	15	15	15	15	15	15	15	15	15
Average:	596	788	922	1030	863	1130	654	595	650	1120
Maximum:	1010	1230	1560	1440	1810	1760	860	722	844	1880
Standard Deviation:	250	202	214	305	333	283	95	66	91	352
	SU-13	**SU-14**	**SU-15**	**SU-17**	**SU-18**	**SU-19**	**SU-20**	**SU-21**	**SU-22**	**SU-23**
Number of samples:	18	15	15	10	10	10	10	10	10	10
Average:	1260	1070	750	788	571	931	847	746	552	780
Maximum:	2720	2060	1050	1440	1400	1520	1520	1440	1440	1440
Standard Deviation:	692	387	136	123	34	82	54	132	66	185
	SU-24	**SU-25**	**SU-26**	**SU-27**	**SU-28**	**SU-29**	**SU-31**	**SU-32**	**SU-33**	**SU-34**
Number of samples:	10	10	10	10	10	10	10	10	10	15
Average:	701	642	843	726	474	542	448	834	449	721
Maximum:	1440	1560	1440	1440	528	614	492	990	633	999
Standard Deviation:	139	54	121	77	51	57	37	79	124	149
	SU-35	**SU-36**	**SU-37**	-	-	-	-	-	-	-
Number of samples:	15	15	15	-	-	-	-	-	-	-
Average:	987	737	936	-	-	-	-	-	-	-
Maximum:	1400	910	1280	-	-	-	-	-	-	-
Standard Deviation:	307	99	241	-	-	-	-	-	-	-

Volumetric Dust Sample Data Summary (pCi/g)

Variable	SU-9	SU-16	SU-30	Difficult-to-access areas	Ref. Area	-	-	-	-	-
Number of samples:	13	12	10	24	10	-	-	-	-	-
Average:	8.0	6.0	4.0	28.0	1.3	-	-	-	-	-
Maximum:	20.6	14.4	8.3	112	2.4	-	-	-	-	-
Standard Deviation:	5.0	5.0	3.0	32.0	0.7	-	-	-	-	-

6.2 RESIDUAL DOSE ASSESSMENT SUMMARY

In addition to evaluating the data against the cleanup criteria established by the ROD, dose calculations were performed to determine the dose to the potential maximally exposed individuals. The detailed evaluations performed to verify compliance with the criteria are included in Appendix B of this report.

The data show that, using the dose models described in the RI and the ROD, doses to potential receptors would be less than the 25 mrem/yr criterion in all SUs. Specifically, the range of estimated doses were calculated as follows:

- < 0.1 to 0.8 mrem/yr for the facility worker
- 0.5 to 19.8 mrem/yr for the utility worker
- all < 0.1 mrem/yr for the demolition worker
- < 0.1 to 3.4 mrem/yr for the dismantlement worker
- all < 0.1 mrem/yr for the recycle worker
- all < 0.1 mrem/yr for the off-site resident

The maximum exposed individual (utility worker) received an average estimated dose of 8.3 mrem/yr assuming he/she splits time between Class 1 and Class 2 areas. This average result is still conservative, but represents a more realistic exposure scenario for the Madison Site. That is, it is unlikely that an individual would spend all allocated time within one small overhead section of the building. These results demonstrate that the 25 mrem/yr limit described in the ROD has been satisfied for all modeled receptors.

7.0 REFERENCES

DoD, DOE, EPA, and NRC, 1997. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, NUREG 1575, EPA 402-R-97-016, December.

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USACE, 2000c. *Final Status Survey Plan for the Madison FUSRAP Site – Madison, Illinois, St. Louis District,* April.

The appendices are not available in electronic format.
Please email lm.records@gjo.doe.gov to request appendices.